

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, DC 20555-0001

February 17, 2010

NRC INFORMATION NOTICE 2010-06: INADVERTENT CONTROL ROD WITHDRAWAL
EVENT WHILE SHUTDOWN

ADDRESSEES

All holders of operating licenses or construction permits for nuclear power reactors under the provisions of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," except those who have permanently ceased operations and have certified that fuel has been permanently removed from the reactor vessel.

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to alert addressees of recent operating experience involving an inadvertent control rod withdrawal event caused by a shutdown activity to isolate the water side of the control rod drive (CRD) hydraulic control units (HCUs) at a boiling-water reactor. The procedure utilized to perform this activity inadvertently replicated the normal control rod withdrawal hydraulic sequence for the last three HCUs isolated, resulting in three control rods being driven out of the core. The NRC expects that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. Suggestions contained in this IN are not NRC requirements; therefore, no specific action or written response is required.

DESCRIPTION OF CIRCUMSTANCES

On November 3, 2008, with Dresden Unit 3 in cold shutdown, three control rods inadvertently withdrew to positions 06, 18, and 16, respectively (control rod position 00 indicates full-in and control rod position 48 indicates full-out). The cause of the event was a deficient procedure performed to isolate all 177 HCUs for CRD system maintenance. The procedure specified sequentially isolating the HCUs with a CRD pump running which established the required hydraulic conditions for outward control rod motion (i.e., insert, unlatch, and withdraw).

The event occurred 10 hours after shutdown (approximately peak xenon concentration) at a reactor coolant system (RCS) temperature of 168 °F. During the event, the reactor remained shutdown with approximately 4.5 percent shutdown margin. However, an inadvertent criticality event could have occurred under different conditions given that the procedure did not place controls on RCS temperature or xenon concentration.

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The following describes how sequentially isolating the HCUs with a CRD pump running established the hydraulic conditions for outward control rod motion (i.e., insertion, unlatching, and withdrawal):

Initial Plant Conditions. All 177 CRD HCU insert valves (HCU 101) and withdraw valves (HCU 102) were open; all 177 CRD HCU directional control valves 120, 121, 122, and 123 were closed; and one CRD pump was operating applying pressure to each of the 177 unisolated HCU under-piston and over-piston areas (see Figure 1). Pressure to the under-piston area was applied through the cooling water header through the open insert valve (HCU 101). Pressure to the over-piston area was applied through the exhaust header (via the orificed check valve) through a designed reverse flow path in directional control valve 121 (which was shut), and then through the open withdraw valve (HCU 102). While the pressures to the under-piston and over-piston areas were roughly equal, a net inward force was applied because the under-piston has a larger surface area (see Figure 3a).

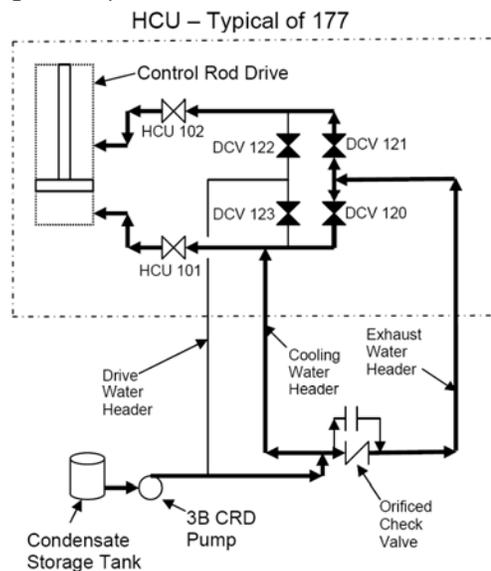


Figure 1 Running 3B CRD pump and flow paths available to the unisolated HCUs

Control Rod Insertion. As shown in Figure 2, the CRD header pressure and proportional net inward rod force was initially small because the flow paths to all 177 unisolated HCUs were available. Using procedural instructions, non-licensed operators began isolating the 177 HCUs one at a time. As each successive HCU was isolated, available CRD header flow paths decreased and since CRD header flow rate remained constant, system back pressure (i.e., CRD header differential pressure) increased resulting in an exponentially increasing the net inward force on the remaining unisolated HCUs. After the 170th (NRC inspector determination) HCU was isolated, the net force to the under-piston area of the seven unisolated HCUs was sufficient to lift the CRD and insert the rod into the over-travel position (Figure 3b). [Note: NRC Inspection Report 05000249/2009009 discusses that the NRC inspector disagreed with the licensee's determination that only 5 control rods (rather than 7 control rods) inserted to an over-travel position.]

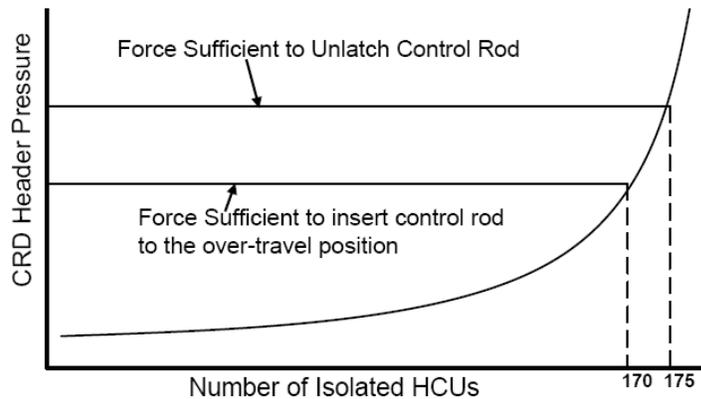


Figure 2 The number of isolated HCUs versus CRD header pressure and the net force applied to the under-piston area of unisolated HCUs

Control Rod Unlatching. When the 174th HCU was isolated, CRD header differential pressure increased such that the control rods associated with the last three HCUs unlatched because of the force applied to the collet piston in the over-piston area was sufficient to compress the collet spring (Figure 3c).

Control Rod Withdrawal. The withdrawal of the three unlatched control rods occurred due to the order the valves were closed to isolate the HCU. By procedure, each of the 177 HCUs was isolated by first closing its insert valve (HCU 101) and then closing its withdraw valve (HCU 102). Closing the insert valve isolated the HCU under-piston area causing this area to depressurize through designed leakage flow paths. After the 175th HCU's insert valve was shut, the associated control rod was free to move out of the core because the rod was unlatched and a net force was applied to the over-piston area (Figure 3d). Outward control rod motion also occurred for the 176th and 177th HCUs for the same reason. Control rod motion continued until the non-licensed operator shut the associated HCU withdraw valve. The three control rods withdrew to the 06, 18, and 16 positions, respectively.

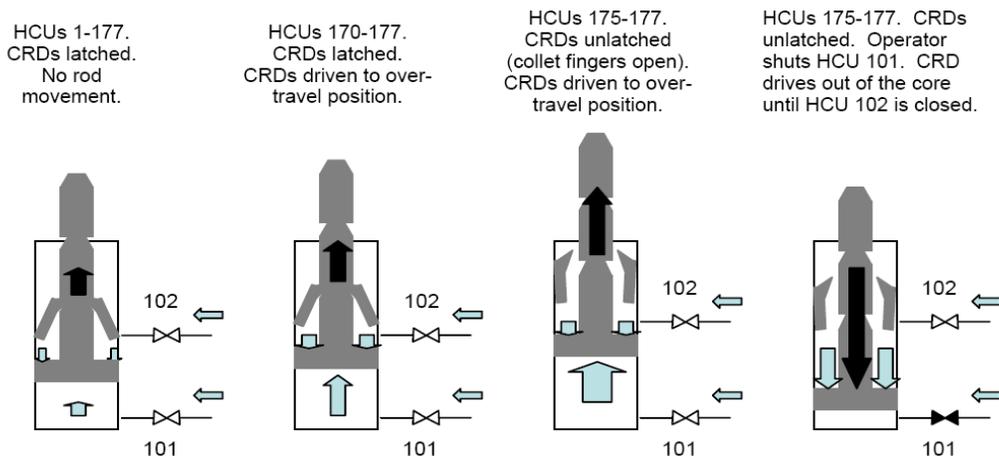


Figure 3a

Figure 3b

Figure 3c

Figure 3d

Figure 3 Status of CRDs

Operator Performance Issues. The licensee found that the main control room was not included in the pre-job brief, control room operators were unaware the activity was in progress or that a non-licensed operator was performing the HCU valve manipulations. This resulted in non-licensed operators manipulating mechanisms with the potential to affect reactivity without the knowledge and consent of a licensed operator at the controls, as required by 10 CFR 50.54(j). In addition, when the main control room received multiple unexpected control rod drift alarms and indications of rods being inserted to the over-travel position, control room operators first pursued whether the alarms may have been caused by known instrument maintenance rather than actual control rod movement. As a result, the first rod drift alarm in the control room preceded the first unplanned control rod motion by almost 18 minutes, and the last three control rods withdrew over the following 3 minutes. When rod movement stopped after the non-licensed operator shut the last of the HCU withdraw valves, the main control room operators no longer had control over any of the 177 control rods. The control room operators did not notice that the CRD cooling water header pressure was off scale high, which covered in the alarm response procedure as potential cause for drifting rods. Approximately 1 hour and 38 minutes after the first unplanned control rod movement, the operators completed the insertion of each of the three control rods by manually cycling the associated HCU insert valves.

Root Cause Evaluation. The licensee determined that the root cause of this event was latent procedural deficiencies. The procedure did not contain any precautions, prerequisites, selection criteria, or limitations for the quantity of HCUs to be isolated with an operating CRD pump. The licensee had previously reviewed operating experience involving control rod withdrawal events at Japanese boiling-water reactors and had implemented procedural changes to prevent this occurrence at the station. However, the licensee had not revised all of the affected procedures, including the one that was used during this event.

The licensee identified the following contributing factors for this event included:

- An over reliance on a computer-based keyword search program system to identify applicable procedures when implementing a procedural change.
- A “shutdown” mindset that did not emphasize that any maintenance on CRD HCUs should be considered for the potential effect on reactivity;
- Operators not trusting their indications and promptly responding to a loss (or potential loss) of control rod control;
- Non-licensed operators performing plant activities (HCU valve manipulations) that could affect reactivity, without the knowledge and consent of a licensed operator present at the controls.

Specific corrective actions taken by the licensee included: identifying and updating all applicable procedures with key recommendations provided in the operating experience; specifying a minimum number of HCUs to be kept in service with a CRD pump operating while shutdown; monitoring CRD drive pressures, rod positions, and alarms during activities that could result in an inadvertent control rod movement; and ensuring that personnel who isolate HCUs are aware that they can affect control rod system drive pressure and cause inadvertent control rod movement.

Additional information is available in Dresden Licensee Event Report 50-249/2008-003-00, dated December 31, 2008, and NRC Inspection Report 05000249/2009009, dated

August 19, 2009. This information can be found on the NRC's public website in the Agencywide Documents Access and Management System, under Accession Nos. ML090090372 and ML092320164, respectively.

DISCUSSION

This event illustrates the importance of licensees understanding that some field activities at boiling-water and pressurized-water reactors can significantly affect reactivity. The regulation at 10 CFR 50.54(j) requires that the operation of apparatus and mechanisms that may affect the reactivity of a reactor shall be manipulated only with the knowledge and consent of a licensed operator present at the controls. In this case, the action of non-licensed operators using a deficient procedure to manually isolate the HCUs in the field led to multiple control rods moving out of the core without the prior knowledge or consent of the licensed control room operators. Moreover, the licensed operators' failure to believe the control room indications unnecessarily delayed their diagnosis of, and response to, the event. Under a different set of initial conditions, this event could have resulted in an inadvertent criticality.

CONTACT

This IN requires no specific action or written response. Please direct any questions about this matter to the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation project manager.

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Note: NRC generic communications may be found on the NRC public Web site, <http://www.nrc.gov>, under Electronic Reading Room/Document Collections.

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